DARK ENERGY SURVEY

A typical day of DES Operations

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Group meeting, January 20th/2015

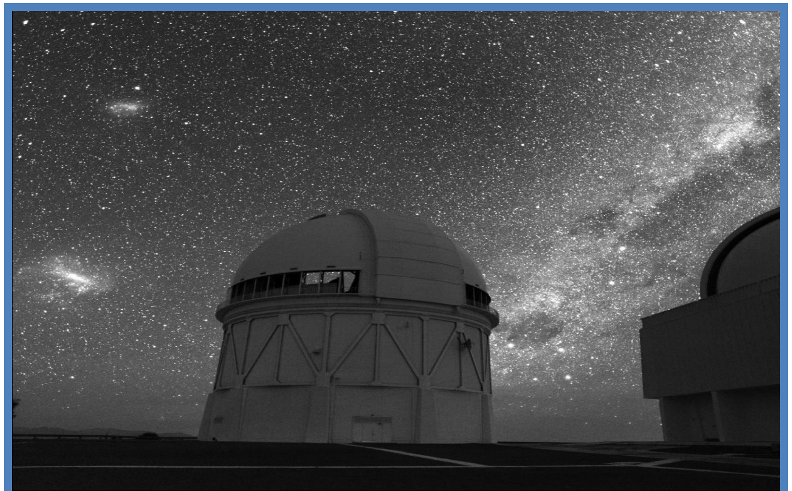
Outline

- The Dark Energy Survey: overview
- The Dark Energy Camera at the Blanco Telescope
  - Few examples of early results
- Observer Roles: Observer 1, Observer 2, Run Manager, Telescope Operators
- **A typical day (and night) at DES in Cerro Tololo**

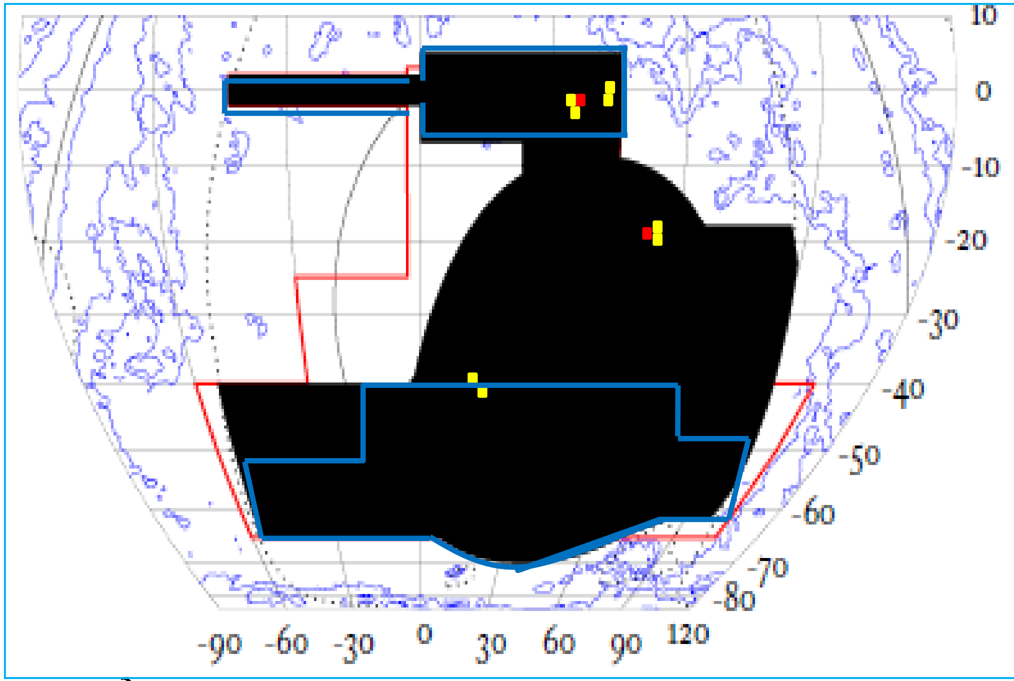
The Dark Energy Survey

DARK ENERGY SURVEY

- 4 complementary techniques to measure acceleration of the Universe
  I. Cluster Counts
  II. Weak Lensing
  III. Large-scale Structure (BAO)
  IV. Supernovae
- Two multiband imaging surveys:
  5000 deg^2 *grizY* to 24th mag
  30 deg^2 repeat *griz* (SNe)



- Built DECam, a 3 deg^2 FOV camera for the Blanco 4m telescope at CTIO
  Survey 2013-2018 (525 nights)
  Facility instrument for astronomy community

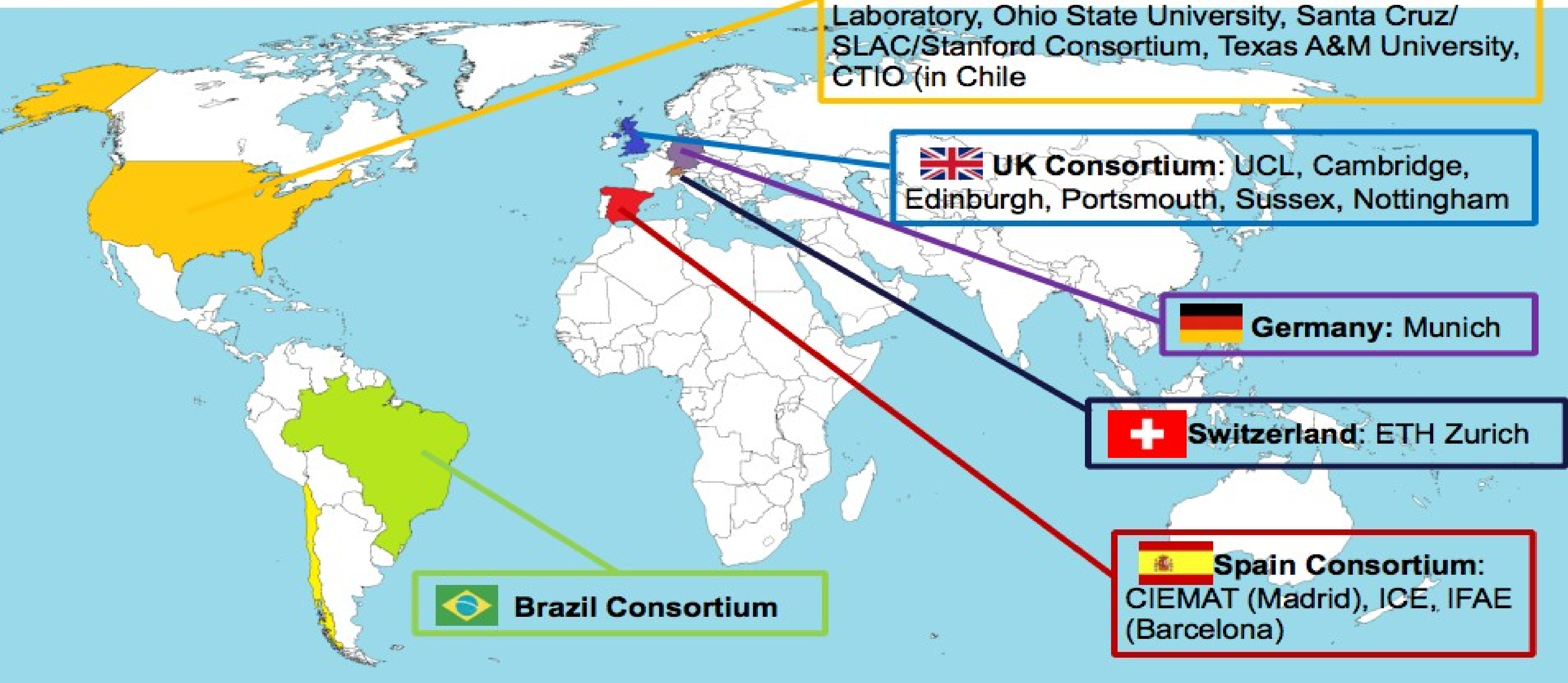


The DES Collaboration

DARK ENERGY SURVEY

~ 300 scientists

facebook.com/darkenergysurvey
http://darkenergysurvey.org



DARK ENERGY SURVEY

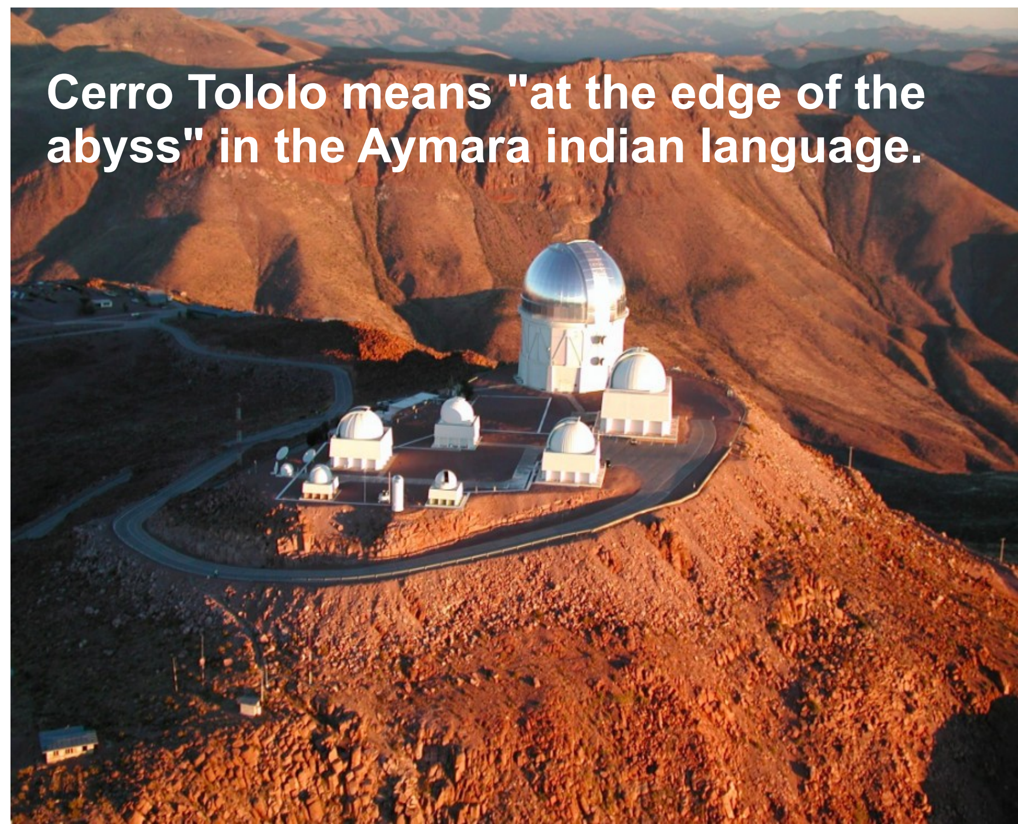
DES timeline

2003	Project start
2004-8	***R&D***
2008-11	DECam construction
2012 [Sept]	***Installation and first light***
2012 [Sept-Oct]	Commissioning
Nov 2012 - Feb 2013	***Science Verification***
Aug 31 2013 - 9 Feb 2014	**First Season (Y1)**
Aug 15 2014 - Feb 2015	***Second Season (Y2)***
2015-2018	***Third-Fifth Seasons***

DARK ENERGY SURVEY

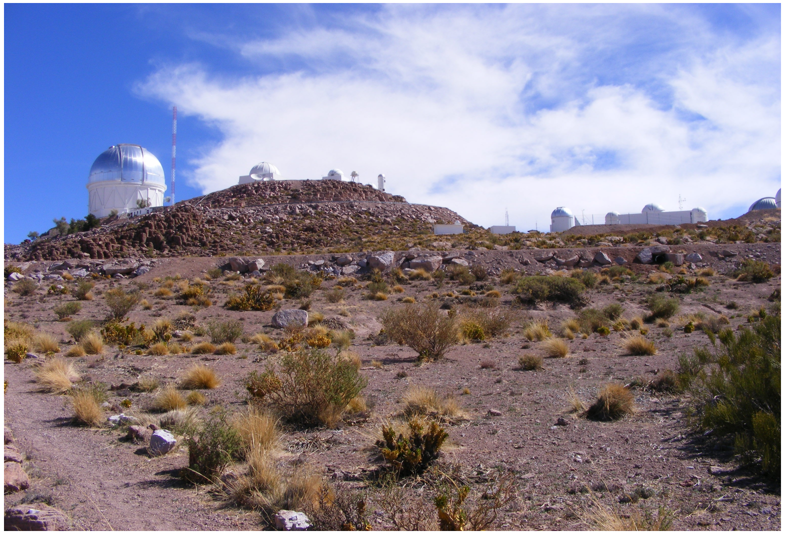
The V. Blanco telescope on Cerro Tololo, Chile

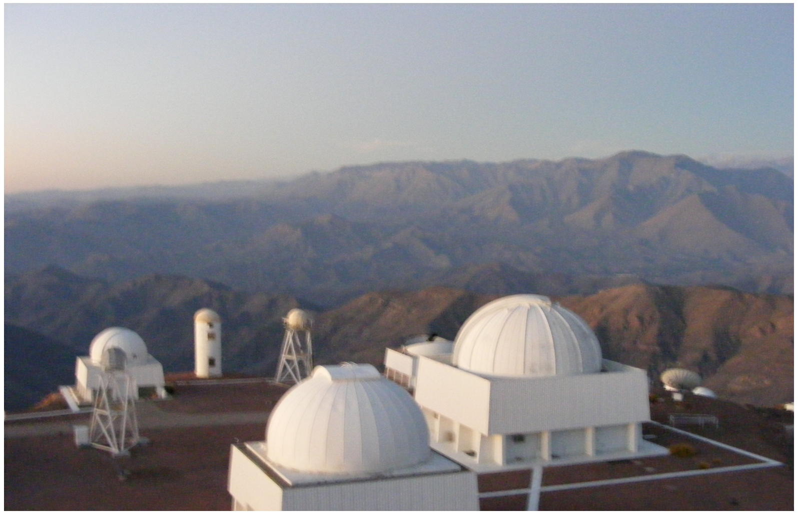
- Cerro Tololo is located about 500km north of Santiago, Chile, about 52km east (80km by road) of La Serena, at an altitude of 2200 meters.
- It lies on a 34,491Ha (85,227 ac.) site purchased by AURA on the open market in 1967 for use as an astronomical observatory.



DARK ENERGY SURVEY

Cerro Tololo





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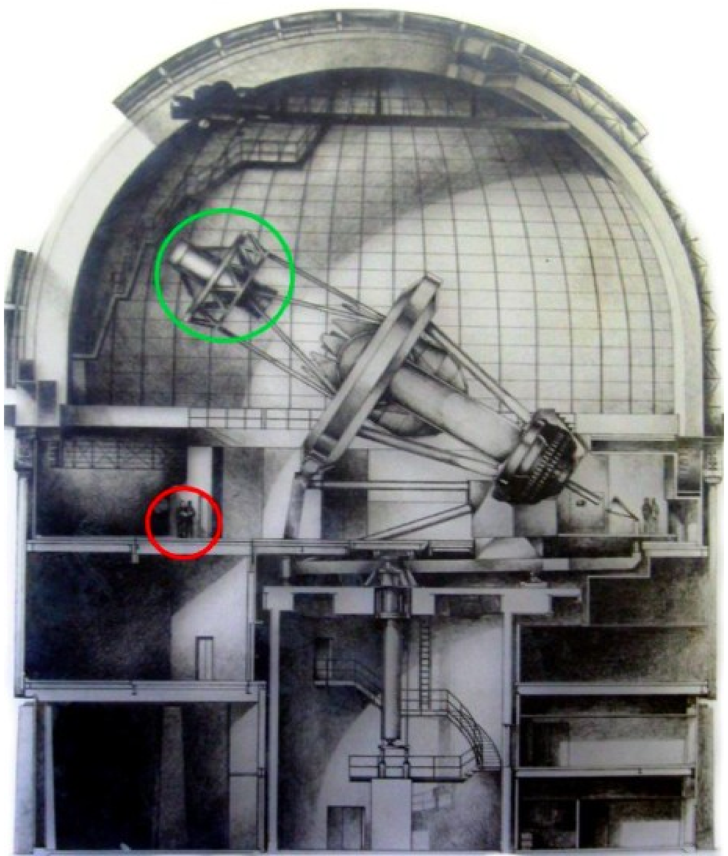
Cerro Tololo

The Dark Energy Camera at the Victor Blanco Telescope

DARK ENERGY SURVEY

- Commissioned in 1974
- Named after Víctor Manuel Blanco (Puerto Rico)
- Ritchie-Chétien telescope (a type of Cassegrain)

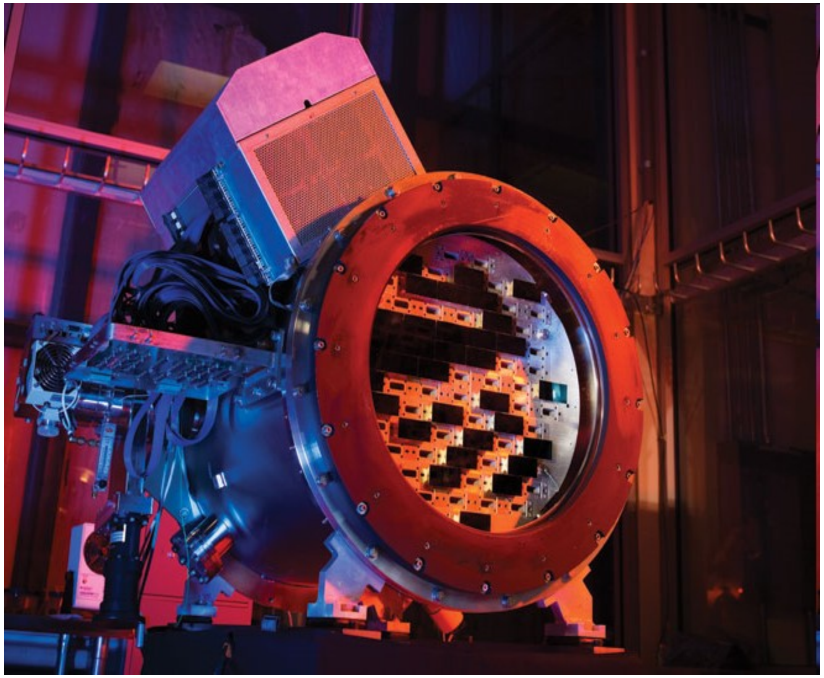


- Primary mirror: ~4m
- DECam is on the prime focus

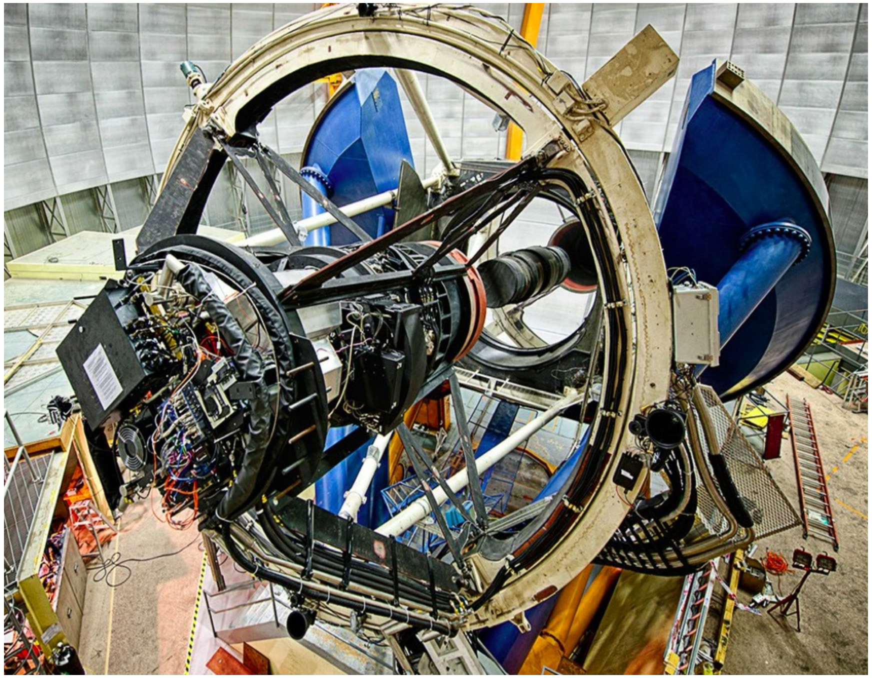
DARK ENERGY
SURVEY

The Dark Energy Camera

DECam: 500 megapixel



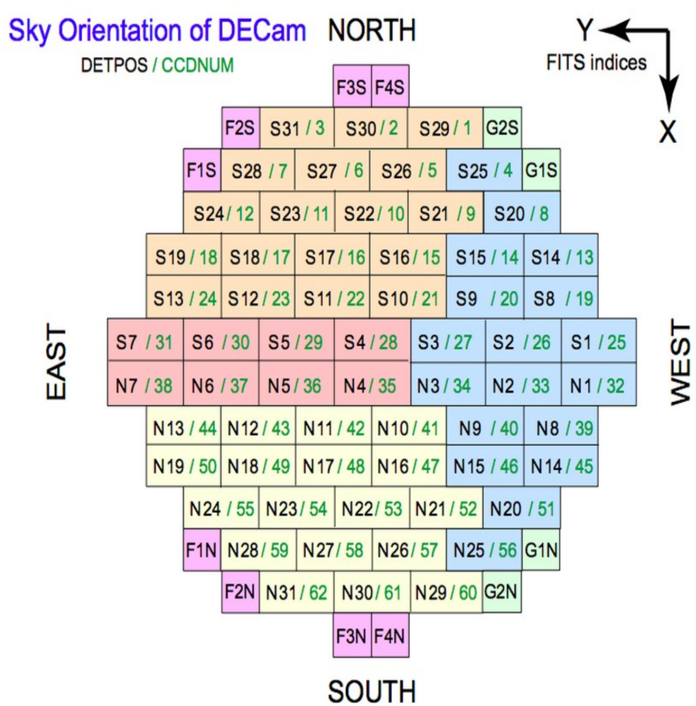
Mounted on Blanco 4-m Telescope



Focal Plane

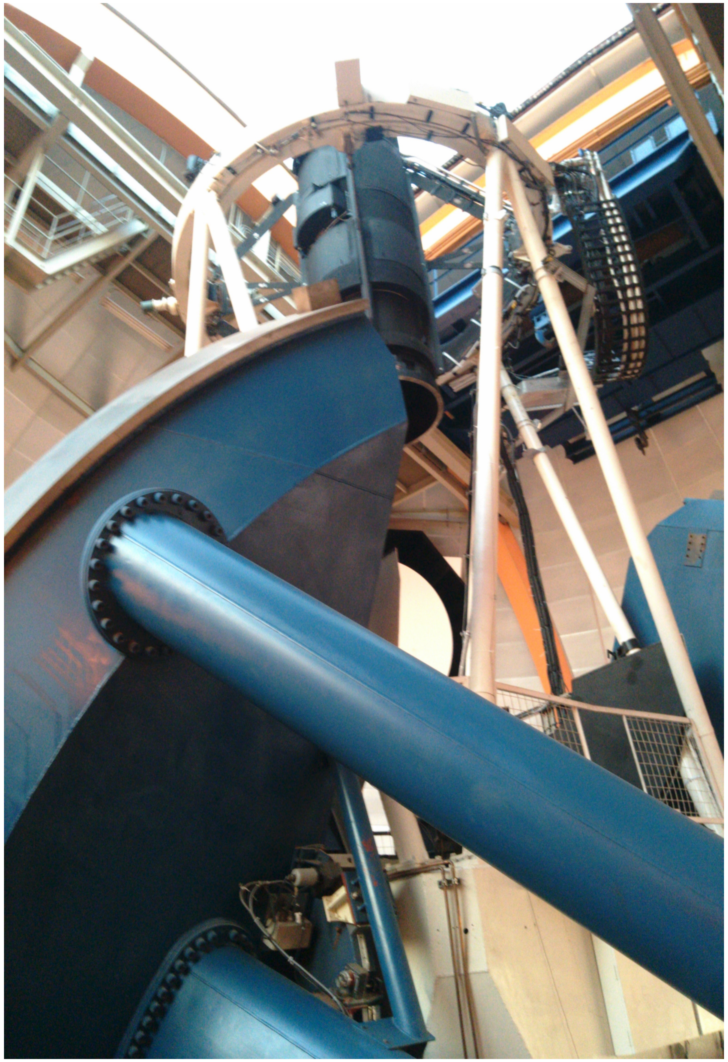
DARK ENERGY SURVEY

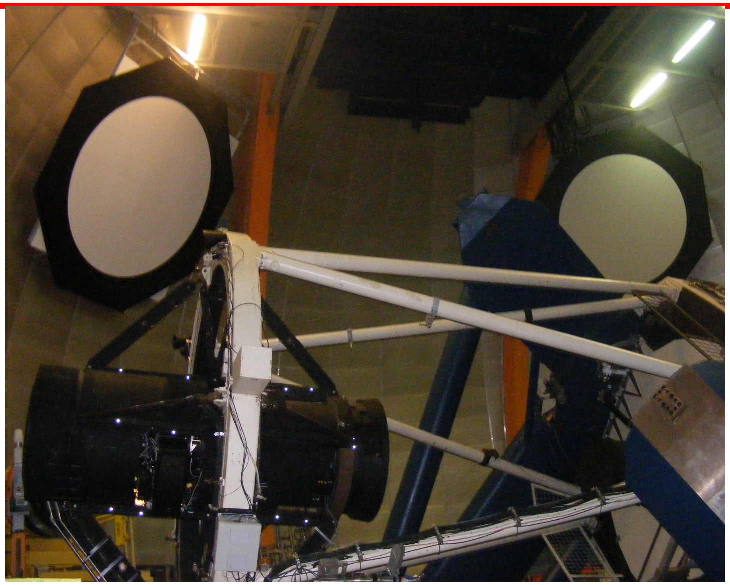
- Focal Plane
  - 62 2K by 2K science CCDs mounted on aluminum plate in a hexagon-pattern
  - Coplanar to 15 microns rms
  - 8 Focus and alignment CCDs are 1.5 mm above and bellow the focal plane



DARK ENERGY
SURVEY

Inside the dome

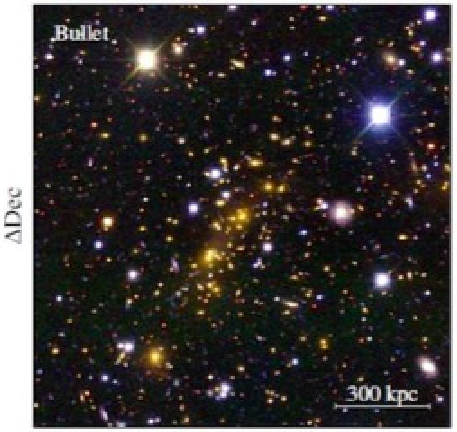




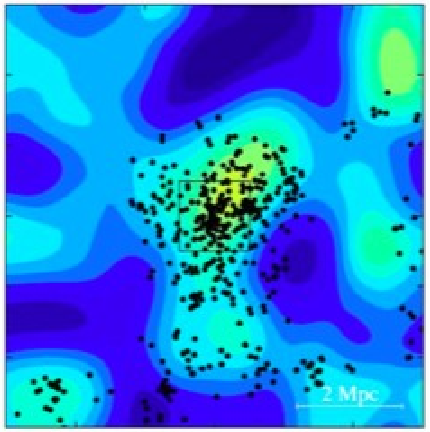
WL: mass of 4 clusters (Melchior et al.,) 1405.4285

DARK ENERGY SURVEY

Multi-color image of the inner 5 arcmin



Map of WL aperture mass significance overlaid with gals inner 30 arcmin



- Measure the masses and redshifts of four known massive galaxy clusters
- Background galaxies identified using photo-z
- Cluster member galaxies identified using photo-z and RedMaPPer
- Weak lensing analysis using im3shape code

Results in very good agreement with previously known measurements

Table 4. Weak lensing masses M_{200c} in units of $10^{14} M_\odot$ (with a flat prior on c_{200c}), redMaPPer richness λ and redshift estimate z_λ, and their statistical errors (see Section 3.2 and Section 5.1 for details). The literature mass estimates are derived from weak lensing, galaxy dynamics (D) or optical richness (R).

Cluster name	M_{200c}	λ	z_λ	Literature value M_{200c}
RXC J2248.7-4431	$17.6^{+4.5}_{-4.0}$	203 ± 5	0.346 ± 0.004	$22.8^{+6.6}_{-4.7}$ (Gruen et al. 2013b), 20.3 ± 6.7 (Umetsu et al. 2014), 16.6 ± 1.7 (Merten et al. 2014)
1E 0657-56	$14.2^{+10.0}_{-6.1}$	277 ± 6	0.304 ± 0.004	17.5 (Clowe et al. 2004)[i], 12.4 (Barrena et al. 2002, D)
SCSO J233227-535827	$10.0^{+3.7}_{-3.4}$	77 ± 4	0.391 ± 0.008	$11.2^{+3.0}_{-2.7}$ (Gruen et al. 2013a), $4.9 \pm 3.3 \pm 1.4$ (High et al. 2010, R)
Abell 3261	$8.6^{+8.6}_{-3.9}$	71 ± 3	0.216 ± 0.003	—

[i] We converted the measured r_{200c} from Clowe et al. (2004), which lacks an error estimate, to M_{200c} using the critical density in our adopted cosmology.

DES can measure galaxy shapes, even in the SV preliminary data set

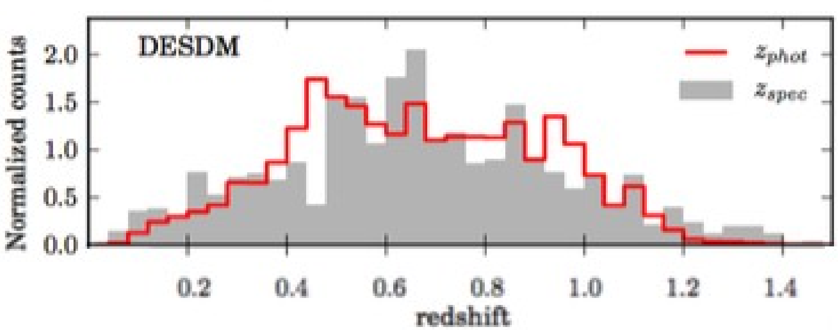
Photometric analyses (Sánchez et al., 2014) 1406.4407

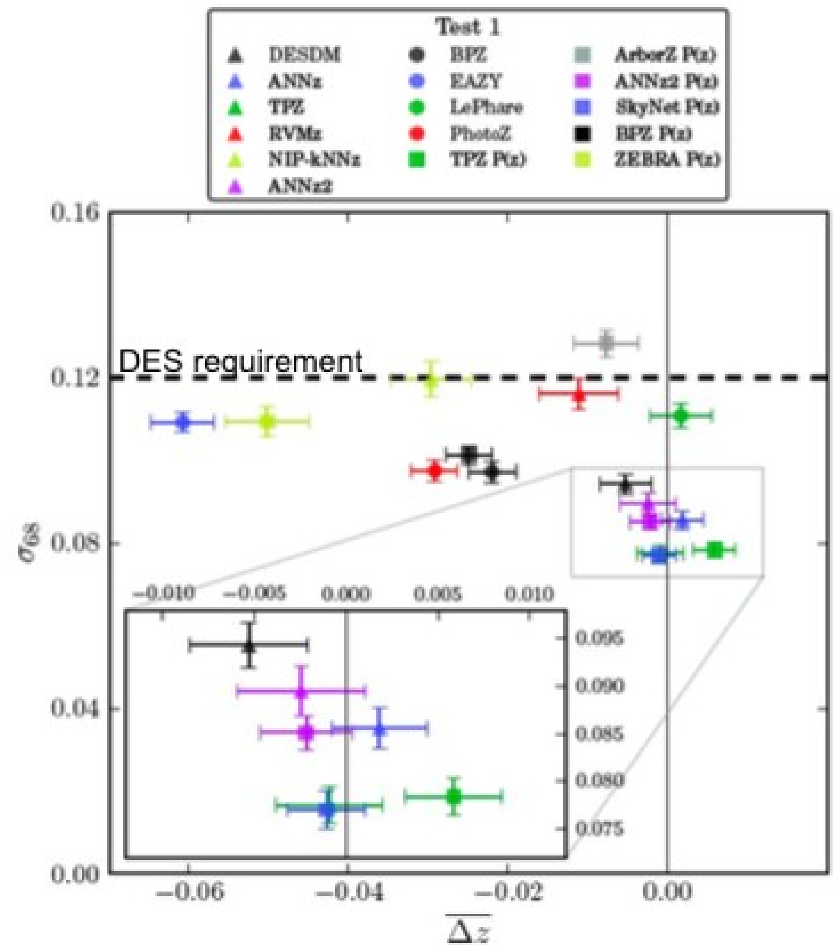
DARK ENERGY SURVEY

Use 15000 galaxies with spectroscopic determination of the redshift (from several previous surveys) for testing and calibrating photoz

Most of the codes meet the DES science requirements, already at this early stage

This paper proves that DES can measure photometric redshifts





Cross-correlation lensing

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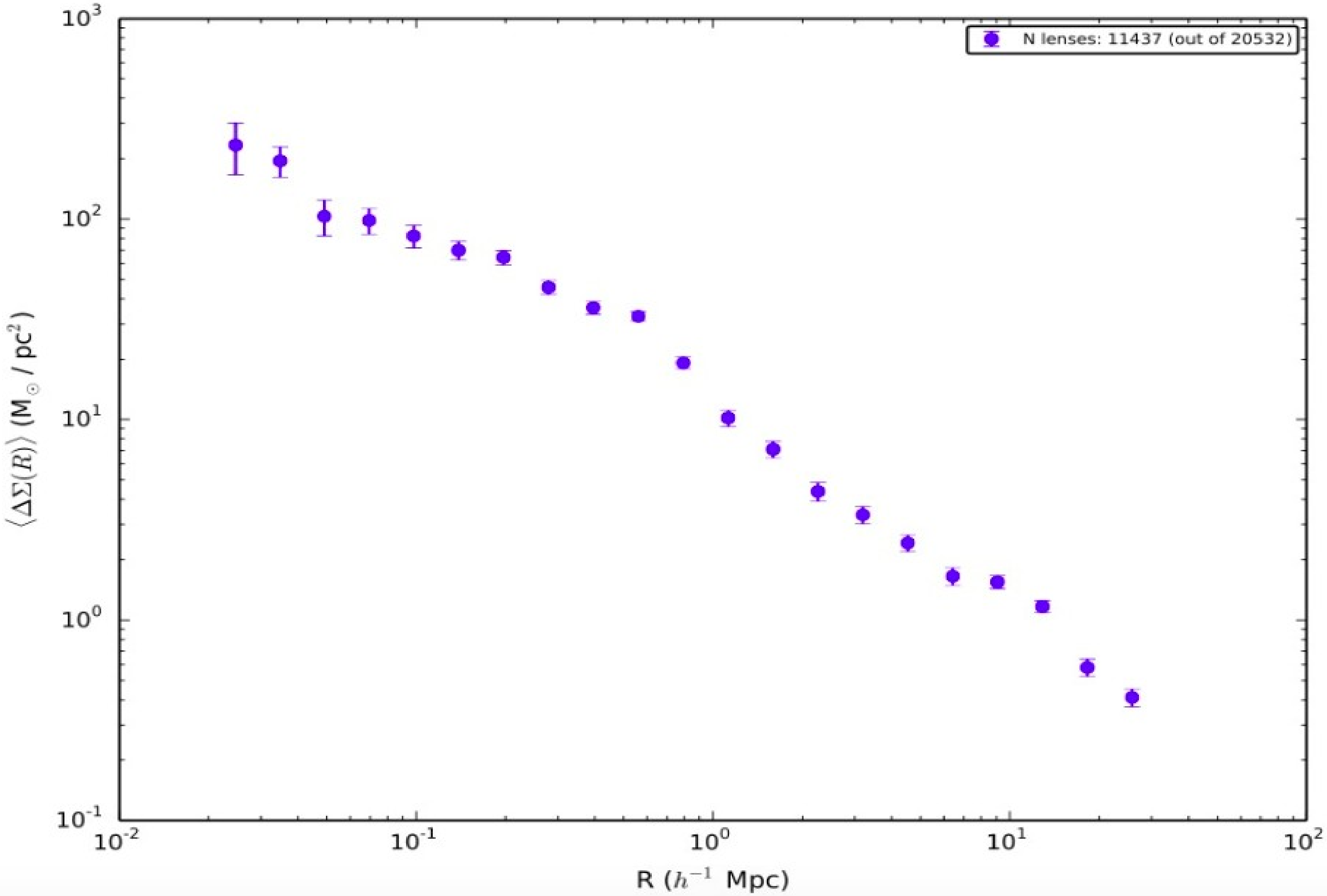
Preliminary result using early DES data!



Sources: ngmix (E. Sheldon)

Lenses: RedMapper

Other papers to be published soon

Galaxy clustering and validation against CFHTLS

DES SV galaxies cross-correlated with CMB lensing

SPT-SZE signatures of DES SV RedMaPPer clusters

Joint Optical and near infrared photometry from DES and VHS

Galaxy populations within SPT selected clusters

DES/XCS: X-ray properties of galaxy clusters in DES SV

The DES SV shear catalogue: Pipeline and tests

Calibrated ultra fast image simulations for DES

DES13S2cmm: The first super-luminous supernova from DES

The DES supernova survey: Search strategy and algorithm

Wide-field mass mapping with the DES SV data

DES Observers & Roles

DARK ENERGY SURVEY

- Observations are staffed by DES Collaborators as a service contribution. We typically have 2 (half-night) to 3 (full-nights) shifters.

- Observing Teams include a mix of experience

- Observer stay from 4 to about 21 nights.

DES Observers & Roles

DARK ENERGY SURVEY

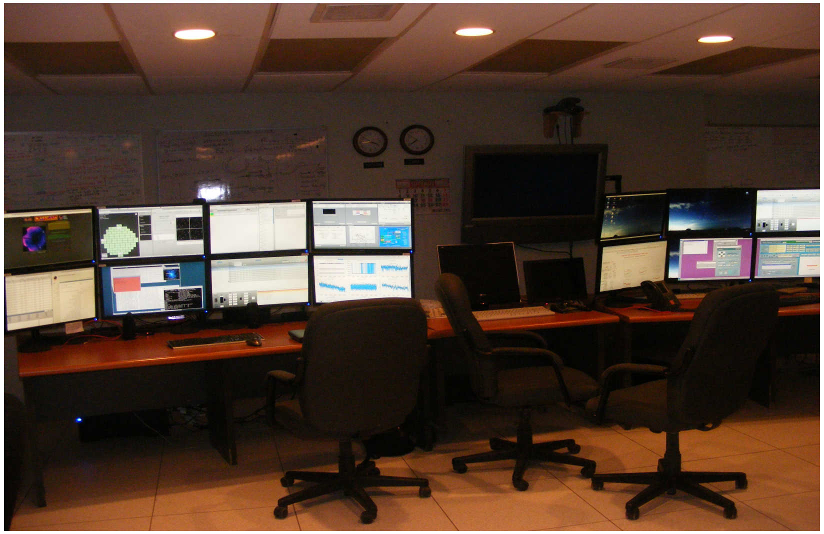
Team

DES has three people at CTIO during survey operations. Two observers (1 and 2) and a Run Manager.

In addition, CTIO staff and telescope operators (Telops) always support operations.

Telops:

The CTIO staff and telops have intimate knowledge of the Blanco telescope and CTIO facilities. They are also very well trained in DECam operations. They keep the camera and telescope safe. The same telop typically stays on mountain for around one week.



DES Observers & Roles

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Observer 1:

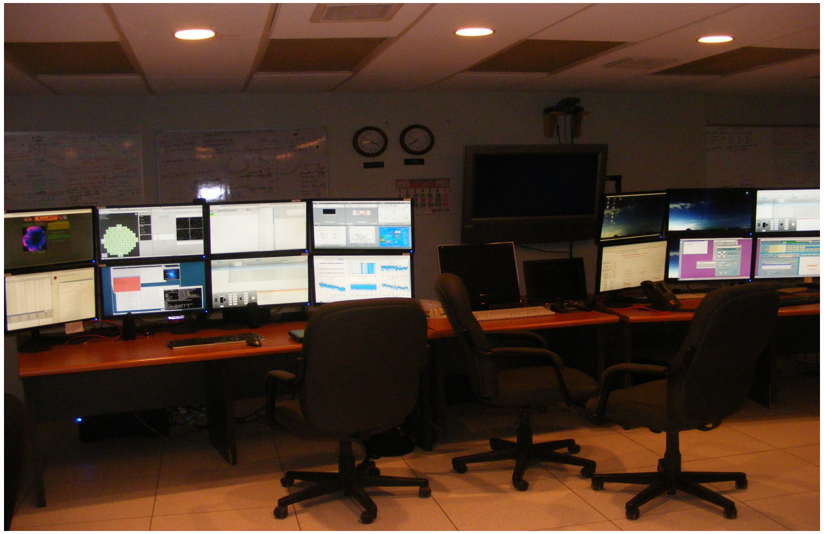
Observer 1 “drives” the survey using the SISPI web interface. They ensure smooth survey data collection. Observers typically stay around one week.

Observer 2:

Observer 2 monitors data quality, weather conditions, manages the electronic log book and files nightly reports. Observers typically stay around one week.

Run Manager:

The DES run manager handles daytime DES operations, reviews night reports, plans observing and connects the DES collaboration, DES observers and CTIO staff. They cover observing duties as needed and train new observers. They transfer knowledge to replacement run managers and tipically stay on a mountain for three to four weeks



DECAm Operations: SISPI

DARK ENERGY SURVEY

- DECam is controlled through the Survey Image System Process Integration Software: SISPI "The Readout and control system of the DECAm" Honscheid et al., SPIE 2012

- Observer sends a request to the Observation Control System (OCS)

- Exposure parameters can be entered: 1) by hand, 2) through a script, or 3) by an automated process that knows the survey history, the current time, and the current observing conditions (e.g, ObsTac)

- OCS then queries the state of the instrument, and then send commands to slew the telescope, to the hexapod controller, and to the filter changer mechanism.

- After this, the OCS opens the shutter, the electronics are triggered to readout the CCDs, and then the image is built.

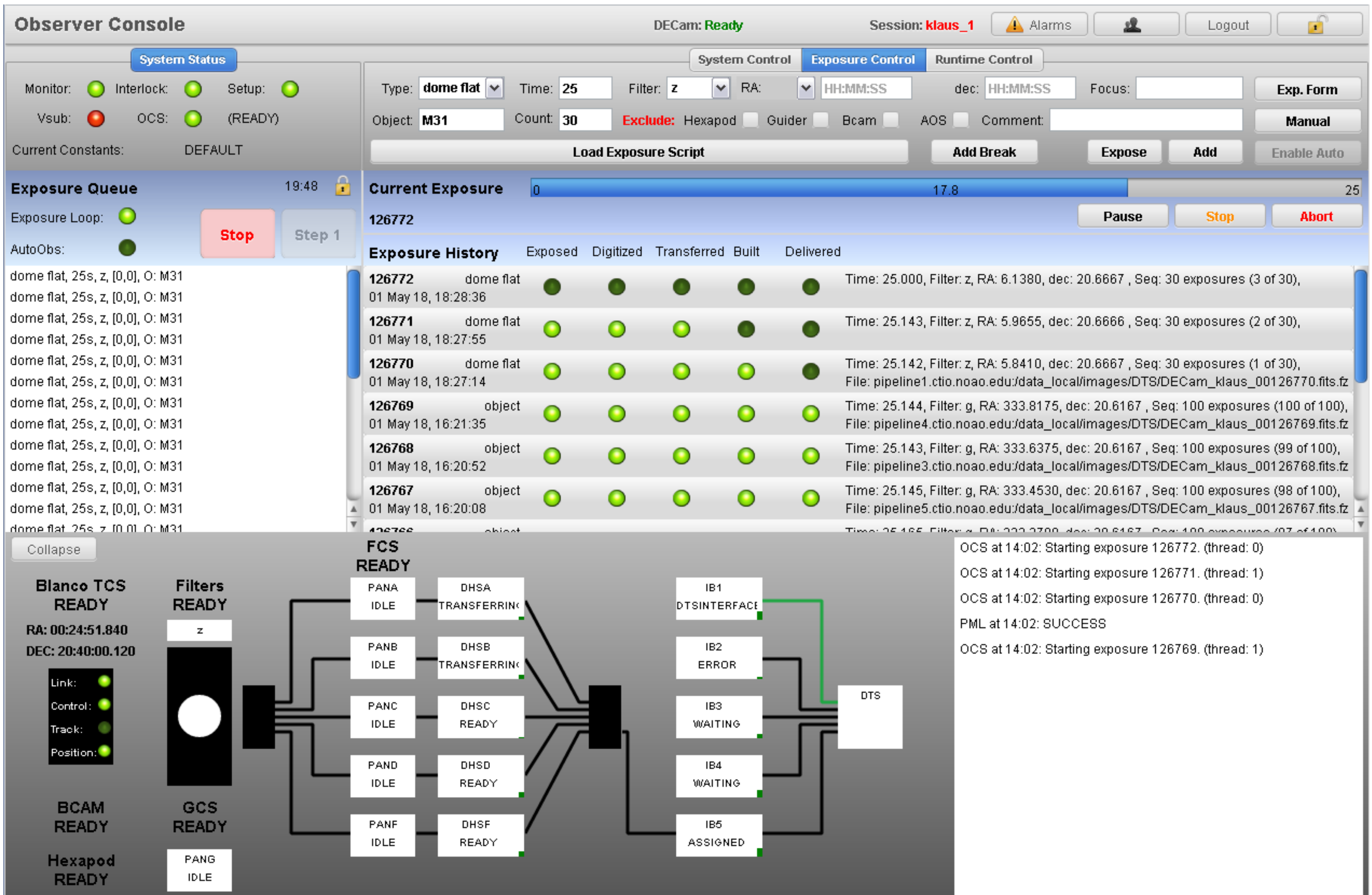
- The data are recorded, and handed over the NOAO data transfer system.

<u>-520 Mpix and 16 bits/pix: ~1GByte per exposure</u>

<u>-250 kpix/s: ~17 seconds to transfer data from focal plane to Image Acquisition System</u>

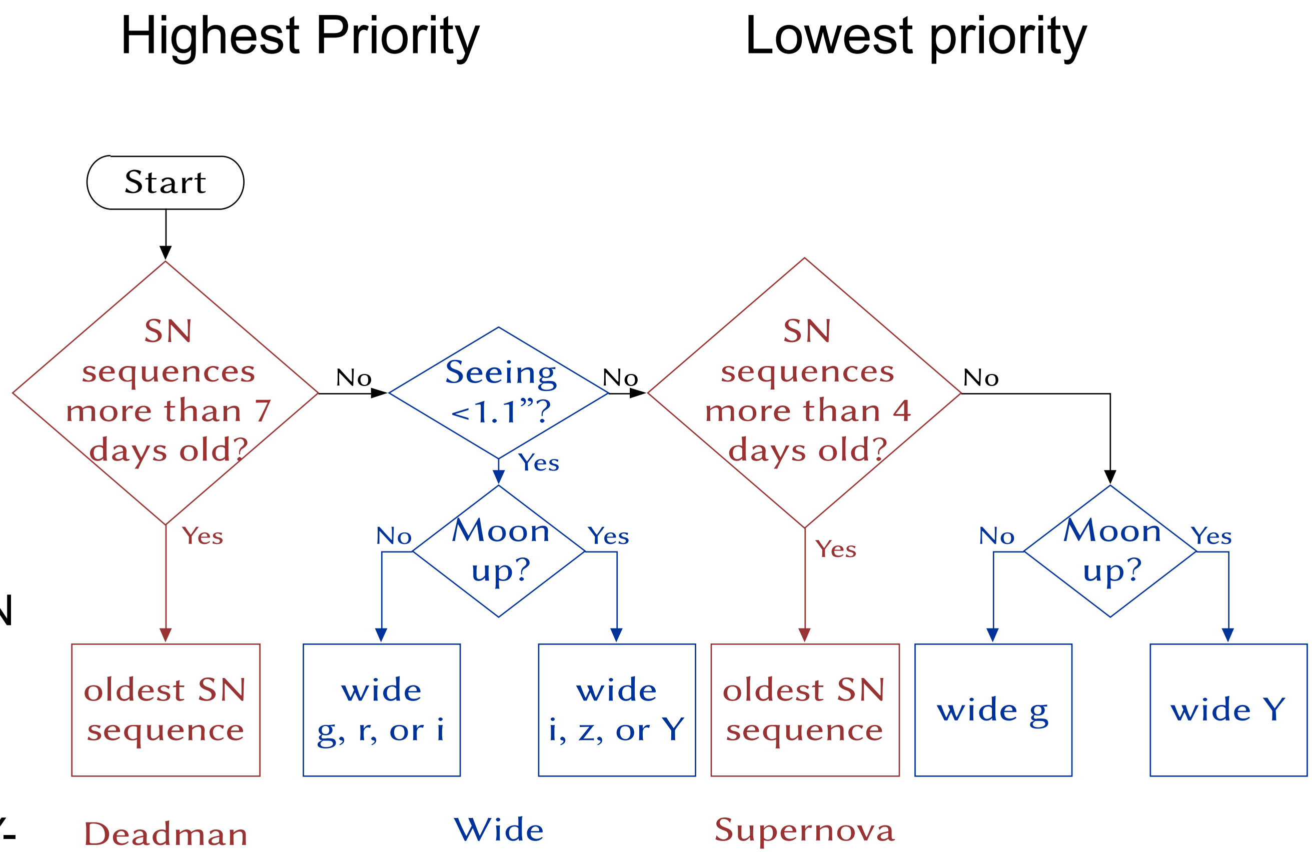
DECAm Operations: SISPI

DARK ENERGY SURVEY



DES Operations OBSTAC

- Observer 1 enables a computer application called OBSTAC that chooses the observations a few minutes in advance, based on priority & current conditions
  - If the weather is ideal, SN are observed under "deadman" with 6-night gaps
  - If poor weather, g-, and Y-band filters (least important for weak lensing)



A typical day of DES operations

(poster at SPIE14 by K. Reil)

DARK ENERGY SURVEY

~ 8:00: Breakfast

DES staff rarely attend. CTIO staff however start any needed day work on the telescope, dome, camera, etc.

~ 12:00: Lunch

Run manager day starts. Prior night reports are reviewed including CTIO report and DES night summary. Check in with subsystem managers to address problems from prior night. Need for 4pm operations phone conference determined.

Run manager meets with CTIO staff to discuss operations issues and get report of day work activities, plan out survey. Night ephemeris, standard star fields selected.

CTIO staff attempt to finish all work prior to 4pm teleconference.

DARK ENERGY SURVEY

A typical day of DES operations

~ 16:00: Daily collaboration wide teleconference.

Review telescope and camera status. Confirm survey plan. Determine any non-survey exposures that may be needed. Telops report on telescope status. Daily dome flat calibrations run.

~ 18:30 Dinner.

Start of day for observers 1 & 2. DES personnel and CTIO staff together. Evening plan discussion occurs. CTIO will meet any dietary needs/restrictions (including annoying vegan diets like mine ;))

DARK ENERGY SURVEY

A typical day of DES operations

~ 1h before sunset

One hour prior to sunset open telescope dome to aid temperature equilibrium.

~ 30m after sunset

Prepare for observations: sensor voltage on, flush sensors, check Rasicam (cloud monitor) is working, start quick reduce (real-time data monitoring), load standard star scripts.

Check dome flats from afternoon calibrations.

https://www.youtube.com/watch?v=i1YsXIsj5CE

A typical day of DES operations

DARK ENERGY SURVEY

~48m after sunset

Observations start. Sun at -10 degrees.

Take pointing exposure (telescope zero point).

Take 3 sets of standard star exposures.

~56m after sunset

Survey operations begin. Sun at -14 degrees.

Observer Tactician (ObsTac) program keeps the exposure queue filled. Switches between supernova fields and DES survey fields automatically.

A typical day of DES operations

DARK ENERGY SURVEY

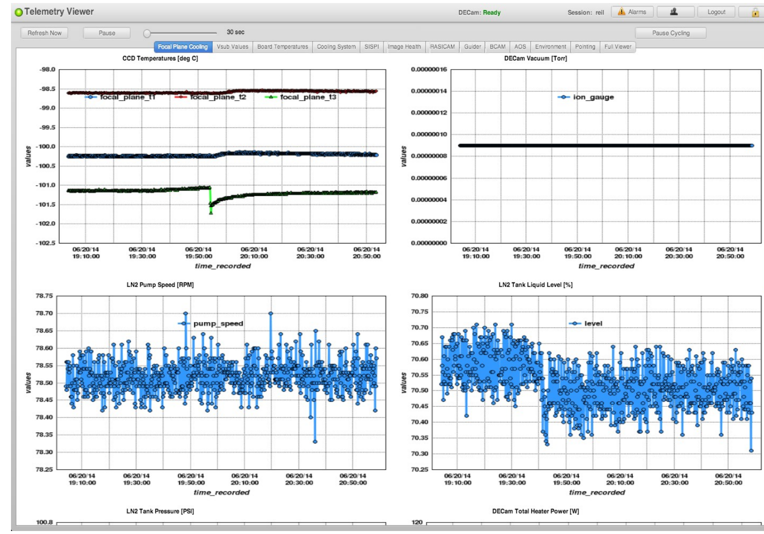
<u>**~1h after sunset**</u>

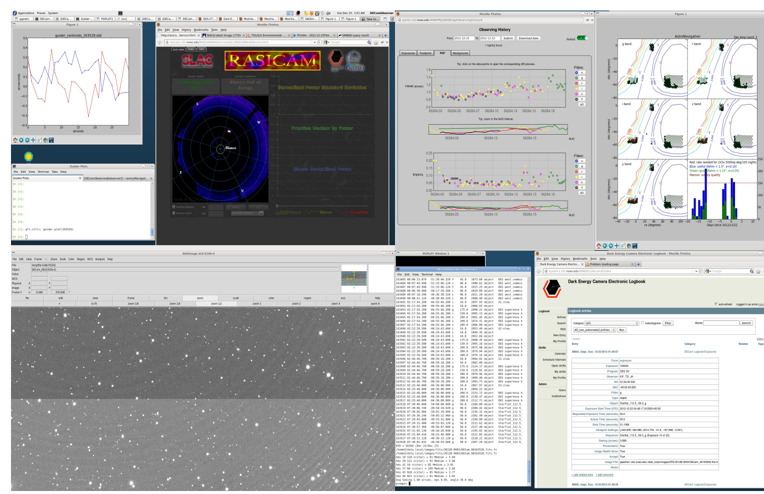
All data taking now fully automated

Observer 1 now monitors telemetry, SISPI performance and data transfers.

Observer 2 monitors data quality using SISPI (fast data quality), “quick reduce” (more detailed data quality), weather (rasicam, satellite, outside)

The run manager ensures that operations are running smoothly. Also provides any required training for new observers.





A typical day of DES operations

DARK ENERGY SURVEY

<u>~1 a.m.</u>

Run manager departs. Observers stay until sunrise.

<u>~1h before sunrise</u>

Around 1 hour prior to sunrise (sun at -14 degrees) automated observation ends.

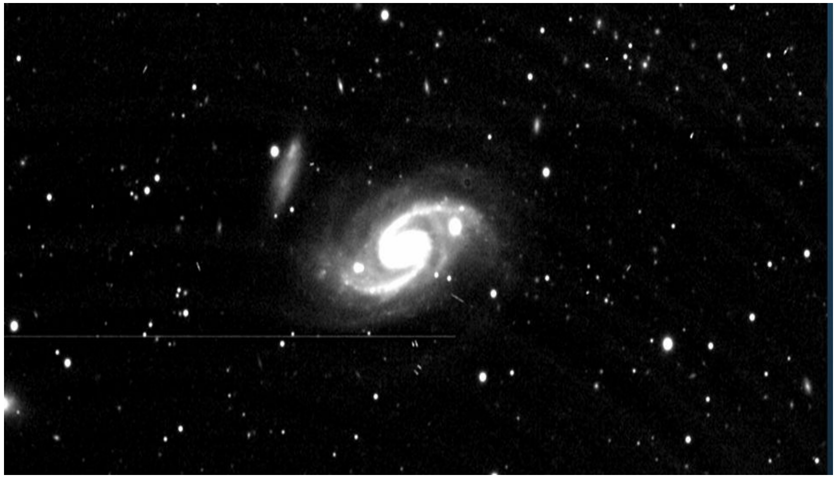
3 sets of standard star exposures are taken.

Night summary (nightsum) log and CTIO telescope log submitted.

Dome closed. Camera and telescope secured.

Morning calibrations if no calibrations prior evening.

Bed around sunrise!



A typical day of DES operations

DARK ENERGY SURVEY

At the end of every DES night a night summary report is generated.

http://decam03.fnal.gov:8080/nightsum/

Night Summary for MJD 56695 (starting evening of 2014-02-06)

Table of contents

Synopsis xml

kent (02/07/2014 01:52:36)

Observing Team

DES Observers: Steve Kent, Alex Drlica-Wagner
Telops: Humberto Orrego, Hernan Tirado
Remote Support: Klaus Honscheid

Observing Plan

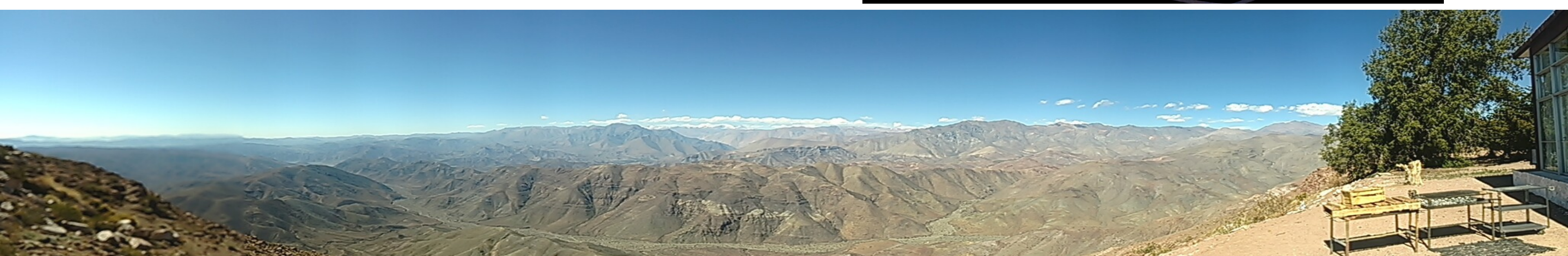
Half-night plan

1. standard bias and dome flat sequence
2. PTC sequence
3. evening standard stars
4. Try to get SN-X3z to load in obstac
5. Nightly defocus
6. run ObsTac queue
7. middle of the night standard star
8. handover to community observers

DARK ENERGY SURVEY

Thanks!

http://www.slac.stanford.edu/~lise/mw2_720.mp4



Extra slides

A day (and night) in life

- Observer 1 - wakes for dinner (maybe earlier), goes to control room, makes sure observer 1 evening checklist ready, drives sispi, night lunch, night reports, nightsum, sunrise, bed
- Observer 2 - wakes for dinner (maybe earlier), goes to control room, makes sure observer 2 evening checklist ready, data quality monitoring, night lunch, sunrise, bed

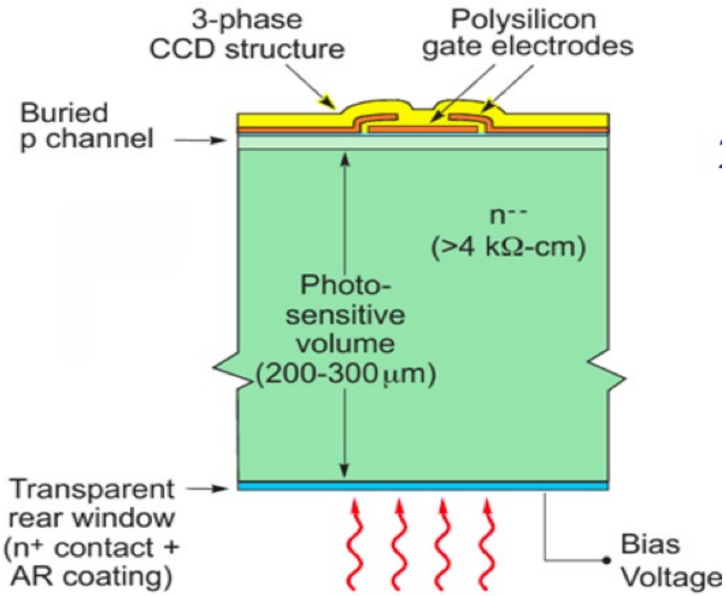
- Run manager - wakes for breakfast, reviews prior nights reports, decides on need for daily meeting, lunch, heads to control room to prepare for evening, gets information from CTIO staff on day work, leads daily phonecan as needed, ensures evening calibrations are run, dinner, control room with observers, make sure everyone knows plan for evening and any updates from phonecon. Start observing, go to bead
- Telops - make magic happen,etc list of all runners and telops.

DES first light (September 2012)

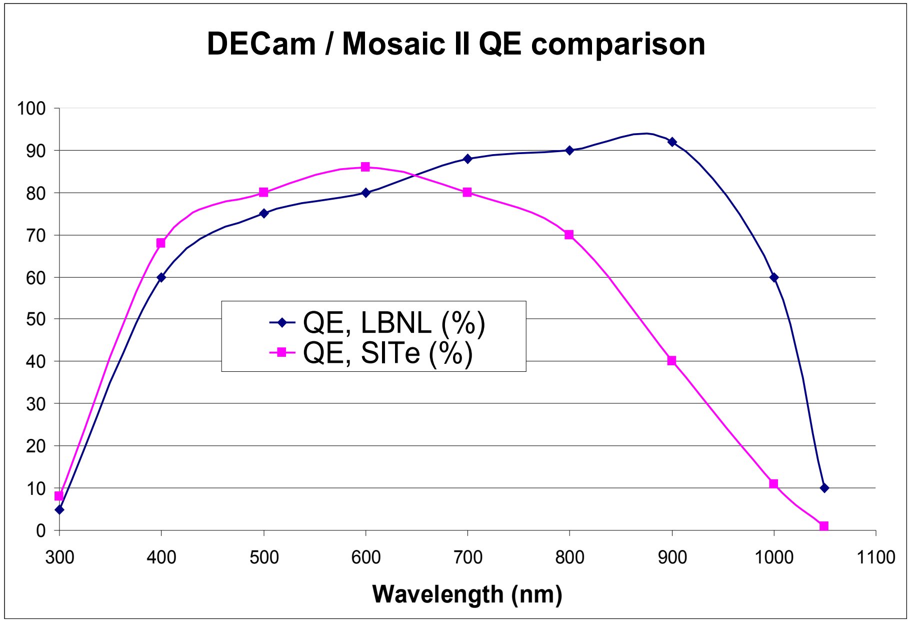
DARK ENERGY SURVEY

DECam detectors: CCDs

• Thick (300 microns), back illuminated, fully-depleted CCDs with high efficiency in the red.



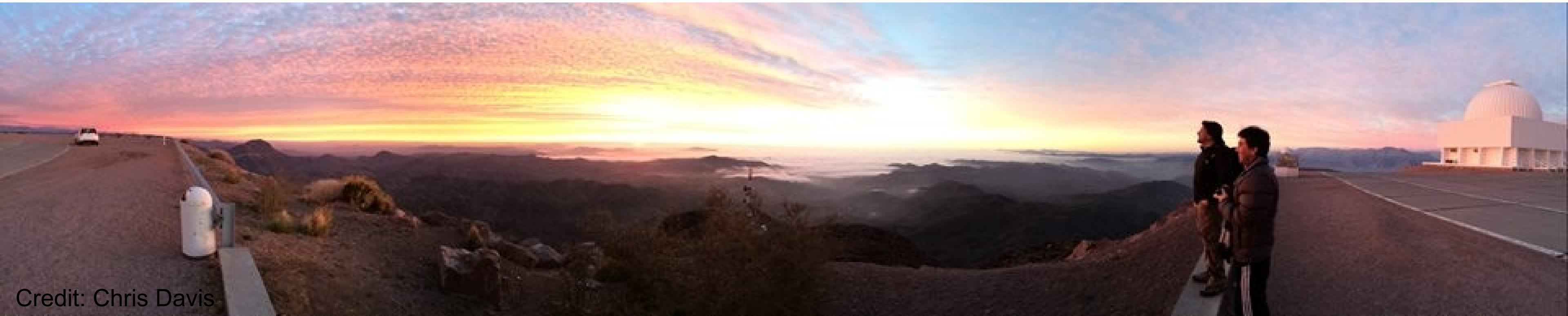
Credit: Holland et al., 2003



However, thick CCDs also leave undesired signatures in photometry and astrometry

Conclusion

- **Weak Lensing** is a powerful tool to learn about cosmic acceleration
- To realize its full potential, a large list of systematic errors must be overcome e.g, shape and PSF measurements, instrumental signatures.
  - Custom tests of DES show that shapelets are not optimal for shape measurement due to noise bias.
  - Atmospheric dispersion can be corrected with color corrections
  - Biases due to tree rings in DES CCDs can be corrected with photometric and astrometric templates
- DES will be one of the best data sets available for WL
  - First measurements of cross-corrleation lensing are promising
- Lessons from shape measurements in DES will be important for future surveys such as LSST, WFIRST-AFTA, and EUCLID.



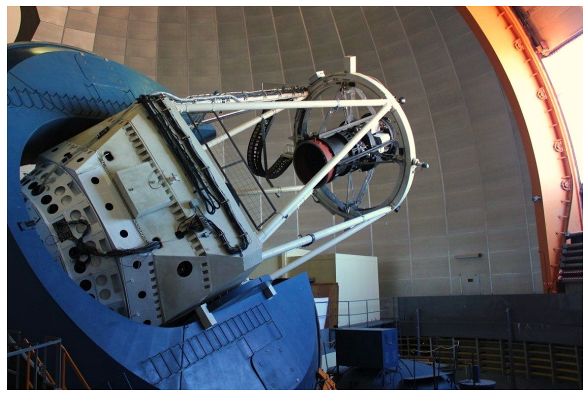
Credit: Chris Davis

Dark Energy Camera

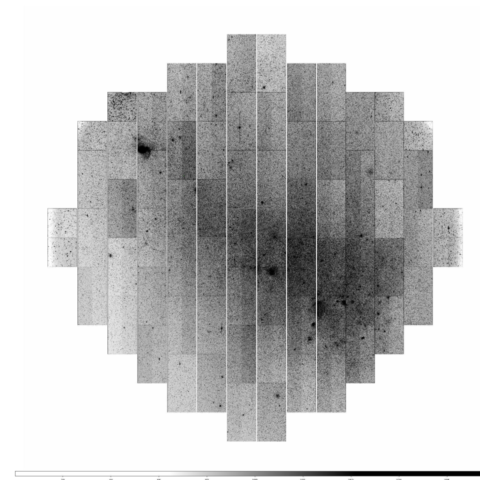
DARK ENERGY SURVEY

Built and tested during ~ 8 years at Fermilab.

Replaced old camera at Blanco telescope.

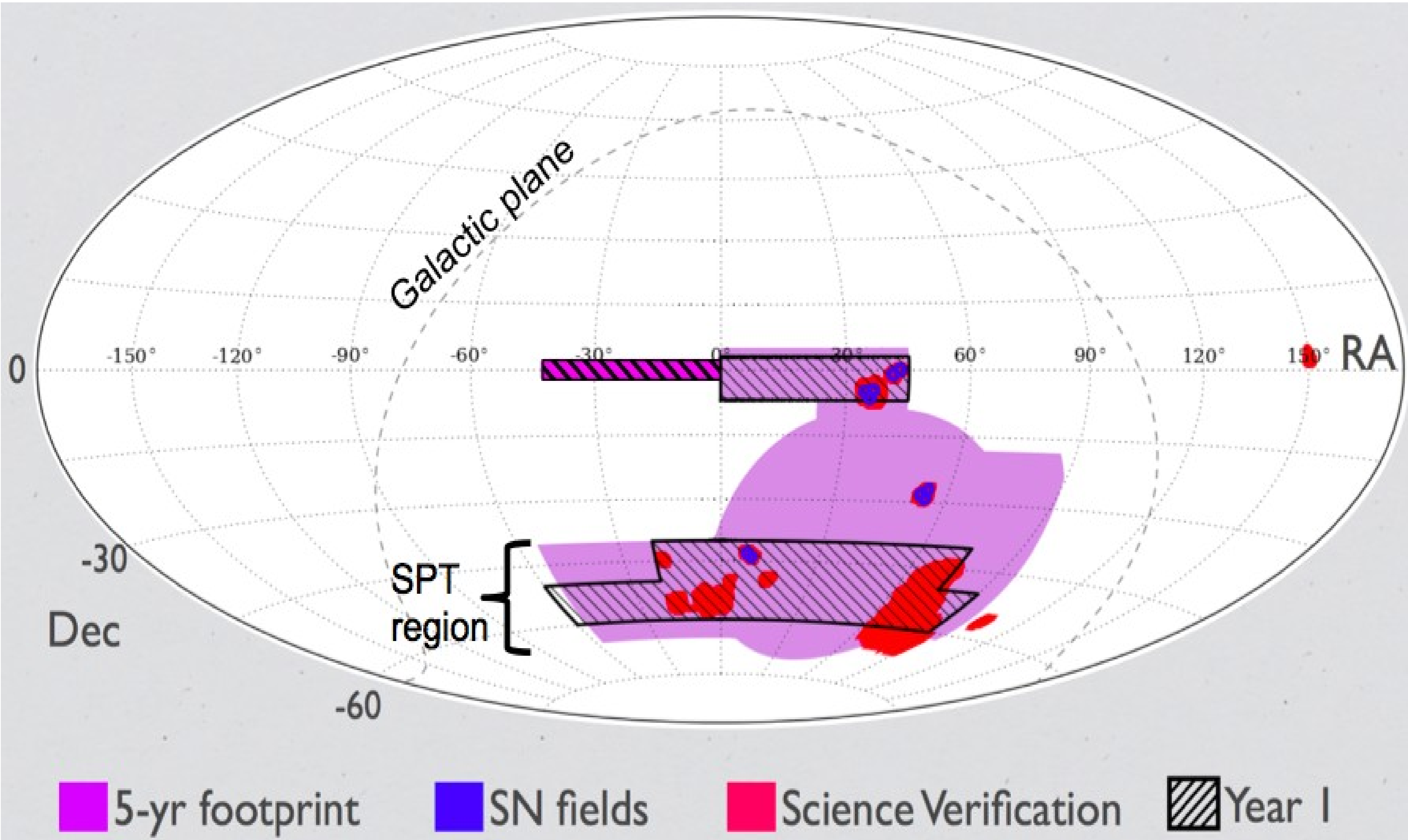


First season: 2013
Second season: 2014



DES footprint

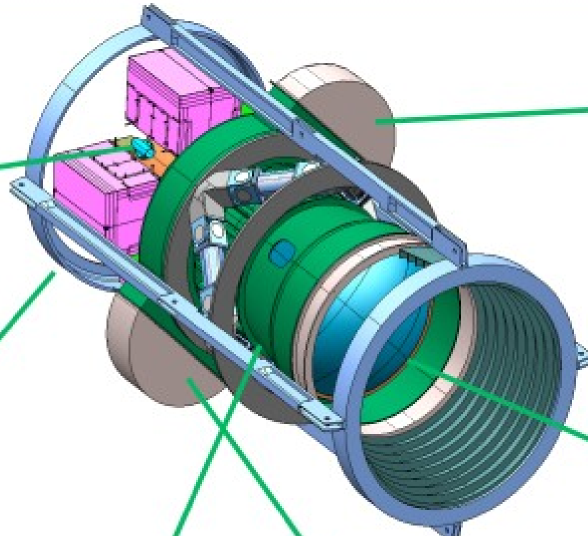
DARK ENERGY SURVEY

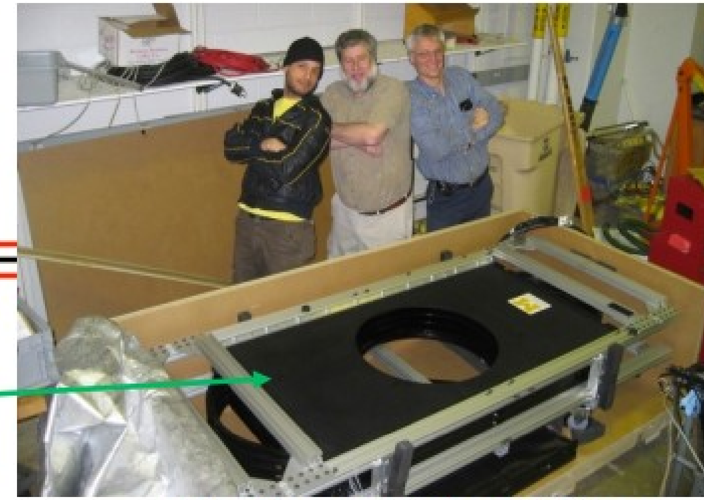


Array Dimensions	
Axis 1:	2048 pixels
Axis 2:	4096 pixels
Pixel Size	15 µm square
Typical Gain	5 e–/ADU
Read noise	7-9 e–
Max. linear count	160,000 to 230,000 e–
CCD Gaps	
in rows (long edge)	3.0 mm, or 201 pixels
in columns (short edge)	2.3 mm, or 153 pixels
Exposure overheads (hardware)	
Readout + clear	17 sec + 3 sec

DARK ENERGY SURVEY

DECam Systems





Filter changer, Univ. of Michigan

Imager, FNAL

Barrel and cage, FNAL

CCDs, wafers from LBL, packaged at FNAL

Electronics, Spain and FNAL

Hexapod, Italy

Shutter, Germany

Lenses, UK

Focal Plane Characteristics

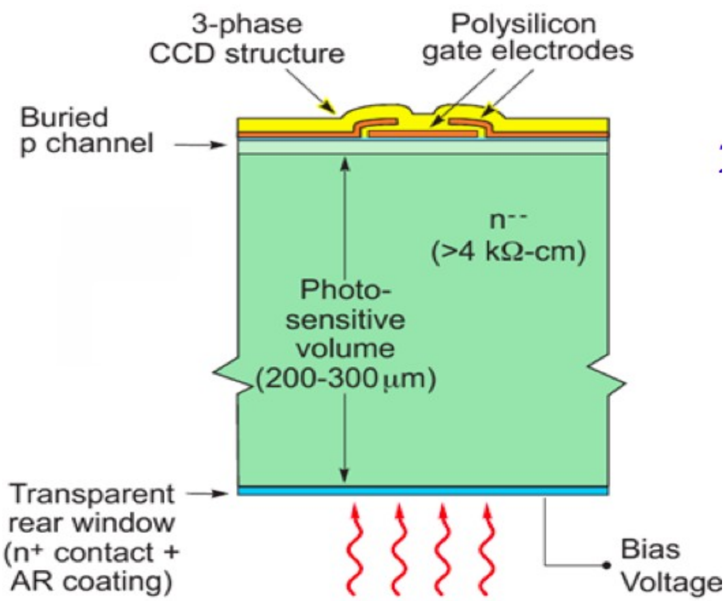
Main Characteristics of Focal Plane

Field of View	3 square degree (2.2 degree field of view)
Pixel scale	0.2637 arcsec/pixel (center), 0.2626 arcsec/pixel (edge)
Detector	62, 2048x4096 pixel red-sensitive science CCDs from LBNL, 520 megapixels total (570 Mpix including guide and focus CCDs)
Read-out noise	7e-
Read-out time	20 seconds
Dark-current	~<25 e-/pixel/hr (spec)
QE	60% at 0.4 mu, 90% at 0.9 mu
Dynamical range	16 bit
Inter-CCD Gaps	3.0 mm (201 pixels) along long edge (e.g., between S4 and N4); 2.3 mm (153 pixels) along short edge (e.g., between N4 and N5)
Cosmetics	Good to excellent. On average, each CCD has 0.05% bad pixels and the worst CCD has 0.39% bad pixels.
Filters	6 filters now available (ugrizY)
Gain	4.5 e-/ADU (typical, provisional 2012-Nov)
Non linearity, < 1% (provisional/conservative)	For normal observing, keep level below 100,000 e-, 22,000 ADU
Raw data format	FITS (with extensions),1 GB/file, ~600 Mbyte/file compressed
Instrument F ratio	f/2.7
Available filters	*u g r i z Y VR*

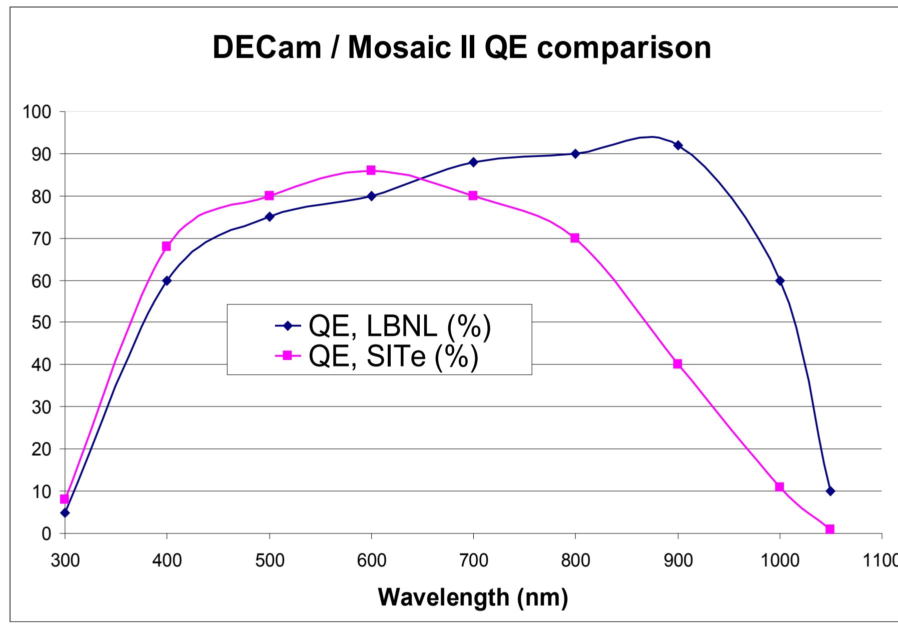
DECam detectors: DALSA/LBNL CCDs

DARK ENERGY SURVEY

• Thick (300 microns), back illuminated, fully-depleted CCDs with high efficiency in the red.



Credit: Holland et al., 2003



However, thick CCDs also leave undesired signatures in photometry and astrometry

The problem of accelerated expansion ("dark energy")

DARK ENERGY SURVEY

We observe an accelerated expansion of the Universe. Why?

- A cosmological constant?
- A new dynamical field (e.g., quintessence)?
- Modifications to our theory of gravity?

We can know more about this by studying:

-The history of the expansion rate of the Universe: cluster counting, SNe, WL, BAO
-The history of the growth rate of the LSS: WL, cluster counting

Large surveys are needed:

-Spectroscopic
-Photometric: photo-z's → **The Dark Energy Survey**